SIMCart 10 with each harness being designed to facilitate the coupling of SIMCart 10 to a particular type of target CS 20. The inclusion of such pre-configured harnesses is contemplated as facilitating the use of SIMCart 10 to test a variety of standard control systems such as Allen-Bradley PLC-5 controllers or Siemens S7 controllers..

Communication channel 160 is preferred to be a TCP/IP based Ethernet network and is preferred to be shared between SIMCart 10 and target CS 20 to allow flexible interaction between HMI 130, I/O simulator modules 120, HMI 230, PLC 270, and I/O interface 220. However, it is contemplated that other communication methods such as RS-232 interfaces, token ring networks, FDDI networks, proprietary control busses, etc. may also be used to provide a communication channel between one or more components of SIMCart 10 and target CS 20.

As previously discussed, the HMI/configurator portion 130 of SIMCart 10 is useful both in the operation of SIMCart 10, but also as a detachable validation and/or training tool. It is contemplated that HMI/configurator 130 comprise the software and one or more databases necessary to allow it to perform its training and/or validation functions. Such functions might include, among others, the ability to control access by requiring an operator to log in, the ability to simulate a particular function and to test the capability of the target CS to respond to a sensor's entire range of input, the ability to prompt the operator to perform operations using the target CS HMI, and automatically performing tests against target CS when such tests do no require manual operations by an operator.

Thus, a particular configurator embodiment is likely to have the ability to store and run multiple tests wherein each test comprises one or more steps. In running a particular test or sequence of test steps, the configurator will prompt the operator to perform a function on the target CS whenever manual intervention by the operator is required, but will automatically (i.e. without operator action) run through any tests steps which do not require such manual intervention. Thus, to test a pump, the configurator may prompt an operator to turn on the pump, then, after the operator has indicated to the configurator that he has turned on the pump, the configurator will ask a question to verify proper operation of the pump such as "Did the pump indicator light turn on?" which the operator can either respond to affirmatively or negatively. If negatively, the configurator will prompt the operator to enter a comment as

to what response by the target CS was actually seen. During another step, the configurator may generate simulated events to which the target CS has automated responses which can be detected by the configurator and in which case the simulator will simply simulate the events and monitor the target CS's response. As an example, if a power voltage level exceeds a threshold amount the target CS may be required to cut off the source of power. Such a test would be performed by the simulator at the appropriate point in a test sequence by sending an over voltage signal to the target CS and monitoring the response of target CS to see if a power cutoff signal is sent. Test results, whether operator responses or automatically monitored events/values are also stored in one or more databases so that an exceptions report comparing actual target CS responses to expected results can be generated.

It is contemplated that the configurator will comprise a scalable library of test databases and test functions utilizing the test databases to perform the test steps. Utilizing database tables to store tests and test parameters allows a tester to add new tests and/or test scenarios, and also to modify parameters for existing tests. Such scalable libraries and dynamic updates make for a much more robust and flexible system.

Figures 12-18 show some of the fields and data which might be included. The table of Figure 12 is an "Alarm" table and includes, possibly among others, the fields TagName, Initial, LL_Limit, L_Limit, H_Limit, HH_Limit, and Deadband. The table of Figure 13 is an "Alarm G" table and includes, possibly among others, the fields Alm_Ind, QNum, Type, and Question. The table of Figure 14 is an "Indication" table and includes, possibly among others, the fields ID, TagName, Description, EUZero, EUMax, and Eunit. The table of Figure 15 is an "PID Loop" table and includes, possibly among others, the fields PID_Number, Loop_Desc, Process_TagName, Min_EU, Max_EU, and EU_Name_SetPoint_TagName. The table of Figure 16 is an "Section IQ" table and includes, possibly among others, the fields ID, SectionNum, SectionStep, and Instruction. The table of Figure 17 is a "Section List" table and includes, possibly among others, the fields Num and Name. The table of Figure 18 is an "SysReqs" table and includes, possibly among others, the fields ID, Section, Requirement, and Question.

SIMCart 10 is contemplated as being particularly well suited for a number of uses when taken to an operational facility and connected in place of all or part of the field wiring

including but not necessarily limited to: (1) testing existing logic for reaction to new scenarios; (2) testing new logic for operations; (3) training process operators prior to an operational campaign to a) score and validate operator readiness, b) identify deficient training areas, and c) ensure operational readiness as an overall team; (4) training process operators at the operational facility using by plugging SIMCart 10 in in place of the plant's actual sensors and actuators; (4) field trouble shooting of wiring and other field related problems.

First Example Application

An example application of SIMCart 10 is its in revalidating a PLC program used to manufacture a drug wherein the PLC does so by controlling ingredient weighing, heating, cooling, tank level control, pump control, and other portions of the manufacturing process. This example refers to target CS 20 as if it were the system to be re-validated. Revalidation of the PLC program of target CS 20 would involve first using the SIMCart 10 to perform off-site testing of target CS 20, and then detaching the HMI/Configurator from the rest of SIMCart 10 and taking it on-site in the field with target CS 20 when target CS 20 is installed at the drug production facility.

During off-site/lab testing, I/O simulation modules 120 are used to provide an input to each of the PLC I/O channels via field I/O connectors 225. The SIMCart automatic initialization routines create a mapping between the target PLC and SIMCart I/O channels. A tester would log into the SIMCart configurator computer/HMI 130 (requiring operators to log in facilitates future auditing). After logging in, test databases are downloaded from a requirements database that was established for target CS 20 at the project start. The test databases are then used to test all functions of the PLC, HMI and network including alarms, loops, and field wiring to satisfy the testing requirement contained in the test databases. Such testing is accomplished via a series of automatic tests, as well as tests which prompt the operator to perform certain actions and to provide responses/inputs to the HMI after performing such actions. The testing of alarms includes the testing of deadbands, and appropriate low-low, low, high, and high-high alarm ranges as well as other types of data deltas. All data can be stored electronically with a date and time stamp as well as with other audit information as necessary.

Once off-site/lab testing is complete, the SIMCart configurator/HMI 130 is datached from theSIMCart and target CS 20 and taken to the field to be used onsite to test target CS 20 once it is installed in the drug production facility. In the field, the SIMCart configurator provides a field tester with a series of tests related to field I/O and wiring connections. For some tests, the field tester is prompted by the SIMCart configurator to instruct a technician, possibly via cell-phone, to input signals to the system which will be passed to target CS 20 via the field wiring. The SIMCart configurator 130 then prompts the field tester to enter responses answering questions related to the feedback HMI 230 of target CS 20 provided to the tester in response to the technician's inputs. All test questions and results are stored so as to allow a report of test results to be generated.

Second Example Application

Once test target CS 20 is installed in the drug production facility, SIMCart 10 can periodically be used to train process operators. Such training can be done on site, using the target CS 20 HMI by simply disconnecting target CS 20 from the plant's sensors and actuators, probably by disconnecting the field wiring, and connecting SIMCart 10 to target CS 20 in place of the sensors and actuators. Once target CS 20 is operating with simulated I/O rather than live sensors and actuators, operators are free to interact with target CS 20 without any fear of consequences to the plant. When used in such a manner, the test procedures used to validate target CS 20 may be used in training operators, or else SIMCart 20 may incorporate specific software and/or data for training operators. Such software and/or data may incorporate multi-media presentations such as training videos. SIMCart 20 may also work partially or completely independently of the operator so as to simulate events, track operator responses to the simulated events, and/or report on the quality of the operator's responses, without the operator having to interact with SIMCart 20 during training.

Thus, specific embodiments and applications of devices and methods for plant control system testing have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described (including the methods shown in Figures 8-15) are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be